

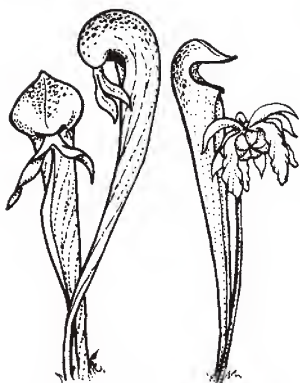
CARNIVOROUS PLANT NEWSLETTER

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Front Cover: There has been much confusion around the identity of the true *Drosera paleacea*, this had recently been resolved with populations matching the type sheet and description found in the Albany area. This species grows in peaty swamps. Photo taken at Frenchman Bay, Western Australia by Richard Nunn. Article on page 13.

Back Cover: Another newly described species, *Drosera bindoon* is endemic to a few small patches of laterite soil north of Perth. Photo taken at the type location near Muchea, Western Australia by Richard Nunn. Article on page 13.

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International Carnivorous Plant Society, Inc.
2121 N. California Blvd., Suite 290
Walnut Creek, CA 94596-7351, USA
icps@carnivorousplants.org

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CPN Editors
Managing Editor
Editor
Editor
Editor
Science Editor
Science Editor

Marcel van den Broek, marcel@carnivorousplants.org
Richard Nunn, richardnunn@carnivorousplants.org
Keith Becker, keith@carnivorousplants.org
Ryan Ward, ryan@carnivorousplants.org
Alex Eilts, Conservation Director, alex@carnivorousplants.org
Jan Schlauer, Cultivar Registrar, jan@carnivorousplants.org
Bob Ziemer, bob@carnivorousplants.org

Sheila Stewart, sheila@carnivorousplants.org
John Brittnacher, john@carnivorousplants.org
Chad Williams chad@carnivorousplants.org
Joe Griffin, joe@carnivorousplants.org

editor@carnivorousplants.org
Bob Ziemer
Barry Rice
Karl Herold
John Brittnacher
Fernando Rivadavia
Jan Schlauer

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MARCEL VAN DEN BROEK • President, ICPS • marcel@carnivorousplants.org

After the successful and exciting 2016 ICPS Conference in London, UK, it is time to select the next location for 2018 ICPS Conference. According to our principle of fair global distribution and the set schedule, the next venue should preferably be located in The Americas. If you or your society feels this should be your turn, please send a proposal by email to marcel@carnivorousplants.org.

In your proposal include information on the person/society (with contact details, including email) who will organize the Conference, the intended venue (capacity, equipment), travel details, accommodation, field trip opportunities, how you plan to make a record of the Conference (proceedings), and any ideas that will assist the ICPS Board of Directors to choose your proposal.

Please understand that, while perhaps interesting, proposals without a direct (personal) commitment to organize the Conference cannot be accepted for serious consideration by the Board.

The ICPS is prepared to distribute information and advertise the forthcoming event to its members and, if requested, a monetary loan to cover advance expenses can be supplied. The conference should, however, be economically self-sustained so any advanced payment by the ICPS can be reimbursed subsequently.

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If you have any questions about what should be in your proposal or what to expect when you try to set up a Conference, you can send your questions to marcel@carnivorousplants.org. A "Conference-manual" containing tips, tricks, and hard earned experience by those who organized a previous Conference is available to help you along the way.

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THE CORRECT NAME FOR *DROSERA LONGISCAPA* AND THE MYSTERY OF
D. MADAGASCARIENSIS FROM SOUTH AFRICA

ANDREAS FLEISCHMANN • Botanische Staatssammlung München • Menzinger Strasse 67 • D-80638
Munich • Germany • fleischmann@lrz.uni-muenchen.de

Keywords: *Drosera curvipes*, *Drosera nidiformis*, *Drosera collinsiae*, Droseraceae, taxonomy.

Summary: *Drosera longiscapa* and *D. madagascariensis* var. *major* are undoubtedly conspecific with Planchon's *D. curvipes*, and hence constitute younger, heterotypic synonyms. *Drosera madagascariensis* s. str. does not occur in the largest part of South Africa, nearly all records previously assigned to that species from former Transvaal and Natal regions belong to *D. curvipes* (or *D. nidiformis* and *D. collinsiae*, respectively).

The amended description provided here is extending published knowledge on the species (Planchon 1848; Burt Davy 1926; Debbert 2002). It is based on own observations of plants *in situ* and in cultivation and on careful studies of herbarium specimens, including type material of all mentioned taxa (herbaria consulted: B, BM, G, K, M, MO, PRE).

***Drosera curvipes* Planch.** - Figure 1

Publication: Ann. Sci. Nat. 3, ser. 9: 196 (1848)

Synonyms: = *Drosera longiscapa* Debbert, = *D. madagascariensis* var. *major* Burt Davy, = *D. ramentacea* var. *curvipes* (Planch.) Sond.

Perennial herb, forming short stems, perennially growing, but usually dying back to the roots in regions with cold winters. Stems up to 5 cm long and 1-1.5 mm wide, covered with remnants of dead leaves from previous season's growth; internodes short, 0.1-1 mm long. *Leaves* of active growth (4)6-10, (1.8)2.5-4.5 cm long, long-petiolate, pale green in shade, tinged bronze in full sun, phyllotaxis alternate, leaves upright when young, then held at about 35° from the main axis (Debbert 2002), old leaves paralleling the stem; stipules papery, translucent brownish, triangular, c. 2-4 mm long, divided into 6-8 segments with acute tips; petiole linear, 10-28 mm long and up to 1 mm wide, with indumentum of short white hairs; lamina narrowly obovate, upper surface with carnivorous tentacles (tentacles base and stalk translucent white, only the capitate head red, a rather rare feature only found in a handful of *Drosera* species; usually the entire tentacle is red), lower surface with indumentum of appressed, simple, white hairs. *Scapes* 1(-3), erect from strongly curved base, terete, 1-1.5 mm wide, up to 30 cm long (Debbert 2002), with scattered, patent, simple white hairs along the entire length (caducous and easily rubbed off, thus not visible in older specimens) and scattered glands in the upper part; peduncle with up to 7 flowers; pedicels 5-6 mm long, covered with scattered glands and patent white hairs. *Sepals* 5, basally connate, narrowly elliptical with acute apex, up to 4 mm long and 1.5 mm wide, indumentum of calyx identical to that of the pedicels. *Petals* 5, free, pale to dark pink, (narrowly) obovate with obtuse apex, up to 6 mm long and 4 mm wide. *Seeds* black, 0.45-0.50 mm long, oblong to narrowly ellipsoid, testa shiny, reticulate, with very regular, narrowly transverse rectangular testa cells.

Phenology: flowering from (October) November to February.



Figure 1: *Drosera curvipes*. A. habit. B. stem and stipules. C. almost stemless specimens. D. the arcuately curved scape. E. leaves. F. Flower. A, C, D from Magaliesberg, North-West Province; B, E near Pretoria, Gauteng Province; F from cultivated specimen.

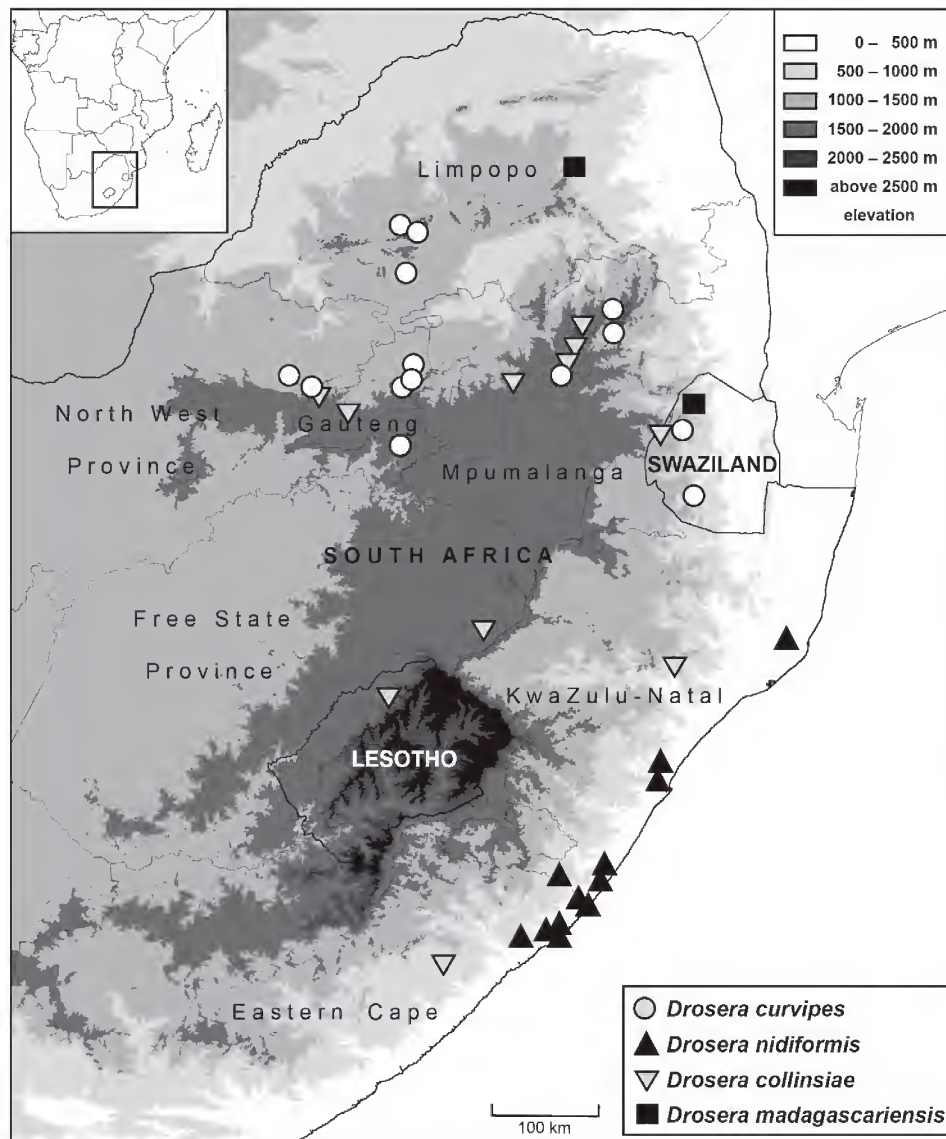


Figure 2: Distribution of *Drosera curvipes* and other taxa formerly erroneously assigned to "*D. madagascariensis*" in north-eastern South Africa.

Etymology: The Latin epithet "*curvipes*" means "curved base" and refers to the base of the flower scape of this species, which is conspicuously arcuated upwards (a character shared with the conatural *D. madagascariensis* DC., however). Not to be confused with the similar sounding name *Drosera curviscapa* T.M.Salter ("curved scape"), for a rosetted plant from the Western Cape Region of South Africa, which is a synonym of *D. aliciae* Raym.-Hamet.



Figure 3: Colony of *Drosera curvipes* growing in *Sphagnum* cushions at a spring in grassy vegetation near Pretoria.

Distribution: North-eastern South Africa (Gauteng, North West, Limpopo, and Mpumalanga Provinces, i.e. the former “Transvaal”) and Swaziland (Shiselweni and Hhohho Districts). Especially in the northern Highveld and the Magaliesberg mountain range (Fig. 2).

Habitat: At elevations from ca. 1000-2000 m. On red sandstone escarpments (Magaliesberg quartzite) in open, wet, nutrient-poor grassland vegetation of swampy patches (“vleis”). In bogs, around perennial springs, waterfalls, or in seepage habitats, growing in *Sphagnum* cushions or in wet peaty soils, sometimes submerged in shallow water (Fig. 3). In South Africa frequently associated with *Utricularia welwitschii* Oliv., *Genlisea hispidula* Stapf, species of *Xyris*, *Lobelia*, Cyperaceae, Eriocaulaceae, and Restionaceae. Often sympatric with *Drosera collinsiae* N.E.Br. in Burt Davy, sometimes also with *D. burkeana* Planch.

Taxonomic affinity: *Drosera curvipes* is closely related to *D. madagascariensis*, as evident from a similar, stem-forming habit, the proportionally very long inflorescence scapes with few-flowered cymes, which are subglabrous in both species (very sparsely covered with simple white hairs and short-stalked, translucent glands in the upper part), and styles which usually are undivided and which bear subulate stigmas in both species (Fig. 4).

Drosera nidiformis Debbert is similar in terms of leaf shape, but without a stem, and with a densely glandular scape. Plants which are morphologically very similar to *D. curvipes*, however with much redder coloration, have been found in Zambia (A. Fleischmann & F. Rivadavia, pers.

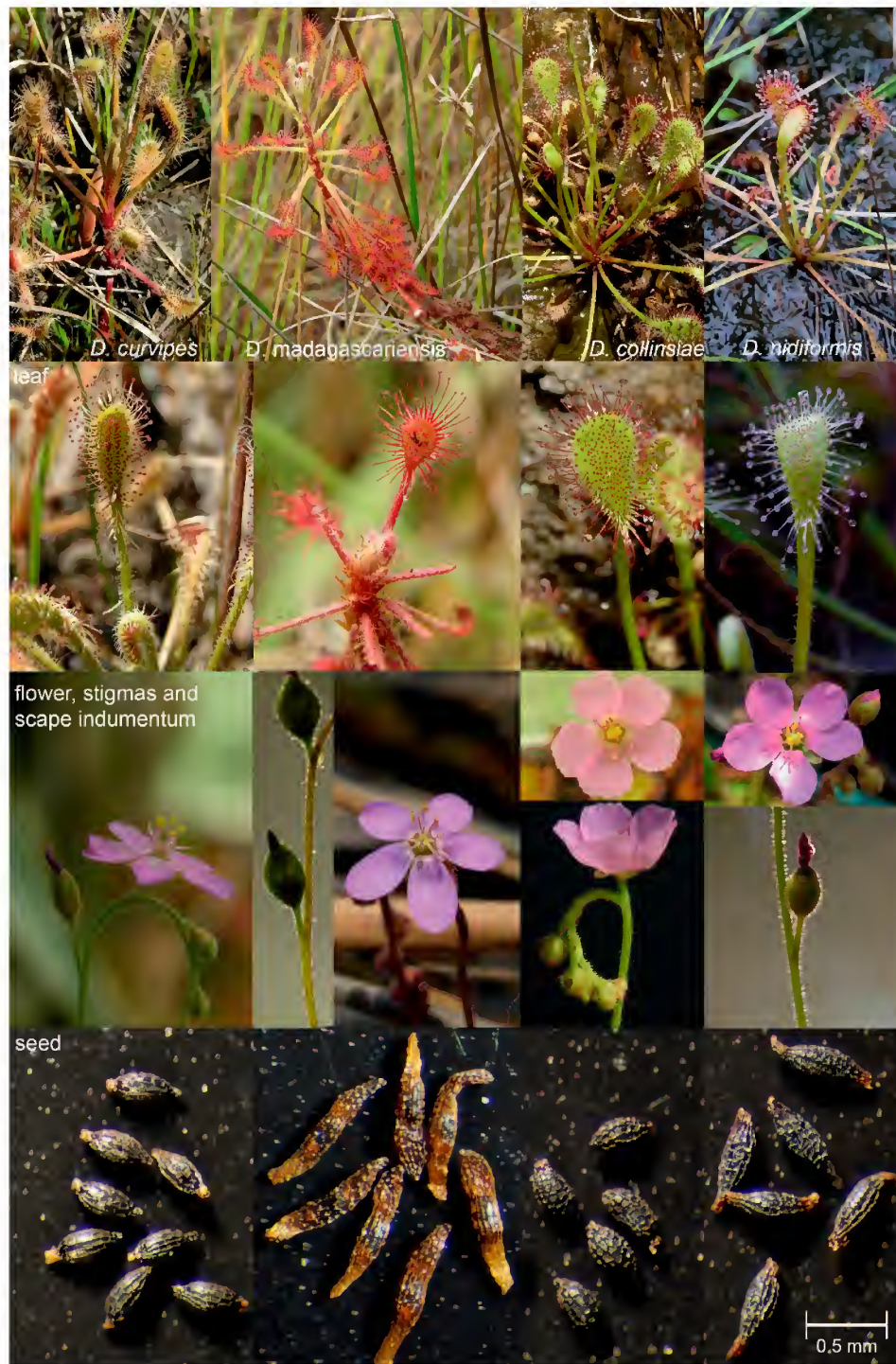


Figure 4: Comparison between *Drosera curvipes* and similar species of north-eastern South Africa. Images in each row of same scale. Photo of *D. nidiformis* in top row by Christian Dietz, all other by Andreas Fleischmann.

Table 1. Comparison of <i>Drosera curvipes</i> with similar species.					
character	<i>D. curvipes</i>	<i>D. madagascariensis</i>	<i>D. collinsiae</i>	<i>D. nidiformis</i>	<i>D. burkeana</i>
habit	stem-forming, old leaves patent	stem-forming, old leaves reflexed	acaulescent, leaves upright	acaulescent, leaves upright	acaulescent, flat rosetted
lamina shape	narrowly obovate	elliptical to broadly elliptical	(broadly) obovate	narrowly cuneate to oblong	transversely broadly elliptical to circular
scape	much exceeding the leaves	much exceeding the leaves	not much exceeding the leaves	much exceeding the leaves	much exceeding the leaves
indumentum of scape (upper part)	subglabrous, with sparse simple hairs and glands	subglabrous, with sparse simple hairs and glands	(dense) simple white hairs and sparse glands	densely glandular	densely glandular
petals	(narrowly) obovate, not overlapping, pink	(narrowly) obovate, overlapping to not overlapping, pink	obovate, overlapping, reflexed at anthesis, pink	obovate, slightly overlapping, pink	obovate, slightly overlapping to not overlapping, white or pink
stigma	usually undivided, subulate	usually undivided, subulate to very narrowly spatulate	divided, bifid to flabellate	divided, bifid to multifid, subulate	undivided to apically bifid, very narrowly spatulate
seed	oblong to ellipsoid, black, testa narrow transversely to rectangular reticulate	fusiform, brown, testa rectangular reticulate	oblong to ellipsoid, black, testa isodiametrically reticulate	broadly fusiform, black, testa rectangular reticulate	ovoid to oblong, black, testa inconspicuously reticulate

obs.), these turned out to be hybrids between *D. affinis* Welw. and *D. madagascariensis*, however, which grew in close proximity to both parent species and which had reduced seed fertility (pers. obs.). In herbarium collections, specimens of *D. curvipes* have frequently been misidentified as *D. madagascariensis* (for obvious reasons), but also with *D. collinsiae*, *D. burkeana*, and *D. natalensis* Diels – to me inapprehensible, because the latter three are very distinctive, and can easily be told apart by the set of characters provided in the identification table above (Table 1).

Records of *D. madagascariensis* from the northern part of South Africa (“Transvaal”, “Natal”), e.g. by Burt Davy (1924, 1926), Diels (1906), Obermeyer (1970), Ross (1972), Compton (1976), Retief & Herman (1997), Nkonki (2003), actually refer to *D. curvipes* (or above-mentioned *D. nidiformis*, *D. collinsiae*, and *D. burkeana*; In particular *D. nidiformis* holds responsible for erroneous records of “*D. madagascariensis*” from the Wild Coast (Transkei) of Eastern Cape Province and from KwaZulu-Natal Province). *Drosera madagascariensis* is a more tropical species, and seems to be fully absent at these higher latitudes (above ca. 26 degrees South) in South Africa. There is only a single confirmed herbarium record from northernmost Limpopo Province (at 23 degrees South; Pott 4609!), but the species is also found in northern Swaziland (Mbabane district, ca. 26 degrees South; e.g. Compton 30503!, and photographs of plants from that region on the web; Fig. 2); it is more common in northern Botswana, Zimbabwe and northern Mozambique (from ca. 20.5 degrees South northwards).

Burt Davy (1926) was obviously aware that the plants of “*D. madagascariensis*” occurring in northern South Africa differed from typical plants (*sensu* DeCandolle), as e.g. found on Mada-

gascar, in having larger laminae and leaves that do not become reflexed towards the stem with age (“Lvs. 8 cm l[ong] tufted at apex of stem, not soon reflexed”, p. 146), when describing his “var. *major*” (the epithet was meant to be referring to the notably longer leaves, but not to the overall height of the plants, which is smaller than that of typical *D. madagascariensis* – thus this variety does not circumscribe the very large and robust plants of *D. madagascariensis* which occur in tropical Western Africa, as might erroneously be assumed from that name). However, he did not notice the similarity to Planchon’s *D. curvipes*, although he studied his type material, nor to the other specimens he listed under the nominal variety of *D. madagascariensis* (including *Wilms 33*, which he also designated as the type of his var. *major* in the same publication) in his treatment “Flora of the Transvaal” (Burt Davy 1926).

Selected specimens of *D. curvipes* examined:

SOUTH AFRICA: Gauteng Province: Transvaal, nahe Pretoria, without date, *Debbert 131* (B, M; type of *D. longiscapa*); [Transvaal. Pretoria Distr.] Macaliesberg [Magaliesberg], without date (received Herb. Hook. 1867), *Burke s.n.* (K, type of *D. curvipes*); Transvaal, [Heidelberg Distr.] Heidelberg, 24.12.1907, *Leendertz 1064* (K); Pretoria, Premier Mine area, 04.02.1940, *Repton 1323* (MO, PRE); Bronkhorstspuit at Donkerhoek, 31.10.1978, *Germishuizen 870* (PRE); Witbank to Pretoria, 1480 m, 04.10.2006, *Rivadavia & Fleischmann 2432* (SPF, M).

North West Province: Transvaal, Rustenburg Distr., 2527 CA, Tierkloof on farm Baviaansk-rans, 02.10.1976, *Venter 1079* (K); Magaliesberg, Mountain Sanctuary Park, 1590 m, 04.10.2006, *Rivadavia & Fleischmann 2431* (SPF, M).

Limpopo Province: Transvaal, near Nylstroom River [Modimolle, Nyl River], *Nelson 293* (K); Waterberg, Geelhoutkop, 05.01.1936, *Van der Merwe 313* (MO, PRE); Transvaal, 16 km from Palala to Bamboeskloof, 09.03.1978, *Germishuizen 744* (K, MO).

Mpumalanga Province: Transvaal, District Lydenburg, bei O’Neil’s Farm, Dez? 1883, *Wilms 33* (K; type of *D. madagascariensis* var. *major*); Transvaal, Belfast, common in pan in wet peaty soil, 6446-6750 ft [ca. 1965-2057 m], 06.02.1904, *Burt Davy 1311* (K); High Forest Stream valley, Buffelskloof Nature Reserve, 1700 m, 04.02.1989, *Burrows 4474* (BNRH photo!).

Not assigned to exact location: Natal, received Jul 1865, *Gerrard s.n.* (K).
SWAZILAND: Shiselweni district, Hlatikulu, 10.1910, *Stewart 10083* (K).

***Drosera madagascariensis* from Southern Africa:**

SOUTH AFRICA: Limpopo Province: Woodbush Hill, 11.1913, *Pott 4609* (PRE).
SWAZILAND: Mbabana, Forbes Reef, 03.02.1961, *Compton 30503* (K, PRE).

Other specimens previously misidentified as “*D. madagascariensis*” (and/or *D. natalensis* in some herbaria) from Southern Africa:

***Drosera nidiformis*:**

SOUTH AFRICA: Eastern Cape Province: Südost-Afrika, Pondoland, 1887, *F. Bachmann 952* (B); Transkei, Mkweniriviermond, 13.07.1976, *Venter 958* (K).

KwZulu-Natal Province: Natal, in paluda pr. Clairmont, 20 m, 22.08.1893, *Schlechter 3133* (G, BM); Clairmont, 12.1882, *Wood s.n.* (BM); Inanda, Natal, 1882, *Wood 1426* (K); Natal, Murchison, 01.05.1884, *Wood 3125* (K); Zululand, Natal, E. of Mtubatuba, 23.03.1941, without collector (K); Port Edward, c. 350 ft. [c. 107 m] 01.1951, *Huntley 778* (K, PRE); Port Shepstone, Uvongo, *Strey 6173* (K).

***Drosera collinsiae*:**

SOUTH AFRICA: Gauteng Province: Transvaal, Witpoortje Falls, 02.05.1949, *Prosser 1215* (K).

Mpumalanga Province: Transvaal, in palude pr. Kl. Olifant Rivier, 1830 m, 21.12.1893, *Schlechter 4022* (G, K); Transvaal, Belfast, 12.1909, *Worsdell s.n.* (K).

Free State Province: Harrismith, 7.500' [= 2.286 m; Platberg], 02.1905, *Sankey 67* (K).

Eastern Cape Province: Nkandla, valley depression at Ngyoa Mountain, 11.12.1973, *Stirton 435* (K); Transkei, Ngadu, N of Umtata, 11.12.1985, *Hilliard & Burt 18782* (K; these are plants with very narrow laminae, perhaps due to introgression with *D. nidiformis*, but scape length, indumentum and sepal shape match *D. collinsiae*).

LESOTHO: Léríbé, Basutoland, *A. Dieterlein 742b* (P photo!).

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THE IMPACT OF SOIL TYPE ON PYGMY *DROSER*A DISTRIBUTION

RICHARD NUNN • Malvern • South Australia • Australia • richardjnunn1@gmail.com

HANS LAMBERS • School of Plant Biology • UWA • Crawley • Western Australia • Australia

Introduction

There are currently 52 species of Pygmy *Drosera* known to science (Lowrie 2014), many of which have only been described in the past few decades. Most of these are endemic to south-west Western Australia with one species, *Drosera pygmaea*, also found in South Australia, Victoria, Tasmania, New South Wales, Queensland, and New Zealand.

Pygmy *Drosera* species differentiate themselves from other members of the *Drosera* genus in two ways; firstly, they reproduce asexually via gemmae, small buds produced in the center of the plant that are an exact clone of the parent. Secondly, they produce stipules at the base of each mature leaf, and these stipules form a tight bud that protects the plant during summer dormancy. The growth cycle of Pygmy *Drosera* species revolves around the arrival of the first autumn rains; most species spend the harsh summer in dormancy and with the arrival of rain send down fresh roots and start producing carnivorous leaves to replenish the plant with nutrients. As winter arrives, and with it cooler temperatures, the plant begins to form gemmae, which are dispersed by the rain. These gemmae in turn send out roots and form an identical clone of the parent plant. As spring arrives, gemmae production ceases and the plants produce flowers, many of which are spectacular and large for the size of the plants. Seed serves as another means of reproduction, ensuring the survival of the plants.

The soils in south-western Australia are severely phosphorus-impovertished and Pygmy *Drosera* species have evolved to survive in these conditions. That there is such a density of species in south-west Western Australia is in itself extraordinary when one compares this with other parts of the world where *Drosera* occurs. The aim of this paper is to introduce the connection between soil type, age, and nutrient level with the evolution and species density of Pygmy *Drosera* species.

Soil types in south-west Western Australia

The landscapes of much of south-west Western Australia have developed on the Archaean granitic basement rocks of the Yilgarn Craton which have undergone little mountain building since the Permian glaciations. This area has largely been above sea level since that time, and as a result, has undergone an extended period of weathering. The resulting subdued landscape of the Darling Plateau is mantled by Tertiary-Quaternary laterites and sandplains on the upland, and duplex soils in the broad valleys (Gibson *et al.* 2004). It is on these laterites and sandplains that Pygmy *Drosera* species have evolved and speciated to the greatest degree, with relatively fewer species found in peat based soils in swampy areas. Some have subsequently moved to the coastal plains that resulted from the accumulation of marine deposit on the west (Swan coastal plain) and south coast (Scott coastal plain), after Gondwana broke up (Wyrwoll *et al.* 2014).

In the Northern Hemisphere, ice-sheets removed much of the pre-Quaternary regolith cover. In contrast, south-west Western Australia has not experienced glacial events since the Early Permian, *ca.* 260 million years ago. The absence of glaciation, coupled to the tectonic stability of south-west Western Australia, has allowed the weathering products to be retained in the landscape (Wyrwoll *et*

Table 1. Pygmy <i>Drosera</i> species and the predominant soil type in which they grow. Some species can grow in multiple soil types. Table constructed using Bourke & Nunn (2012), Erickson (1968), and Lowrie (1987, 1989, 1998, 2014).		
Species	Soil type preference	notes
<i>Drosera allantostigma</i>	pale sand	
<i>Drosera androsacea</i>	pale sand	
<i>Drosera australis</i>	pale sand, laterite or peat	
<i>Drosera barbigera</i>	laterite, yellow sand over laterite	
<i>Drosera bindoon</i>	laterite	
<i>Drosera callistos</i>	laterite, pale sand over laterite	
<i>Drosera citrina</i>	yellow sand	
<i>Drosera closterostigma</i>	pale sand	
<i>Drosera coalara</i>	pale sand, pale sand over laterite	
<i>Drosera coomallo</i>	laterite	
<i>Drosera depauperata</i>	peat	Peat-based soil also contains pale sand
<i>Drosera dichrosepala</i>	laterite	
<i>Drosera echinoblastus</i>	pale sand	
<i>Drosera eneabba</i>	pale sand	
<i>Drosera enodes</i>	peat	peat based soil also contains pale sand
<i>Drosera gibsonii</i>	laterite	
<i>Drosera grieviei</i>	yellow sand over laterite	
<i>Drosera helodes</i>	pale sand	
<i>Drosera hyperostigma</i>	laterite	
<i>Drosera lasiantha</i>	laterite	
<i>Drosera leioblastus</i>	pale sand	
<i>Drosera leucoblata</i>	pale sand	soils often have organic matter and peat content
<i>Drosera leucostigma</i>	pale sand	tends to grow in the wetter areas and soils have more organic matter
<i>Drosera mannii</i>	peat	can grow in laterite as well at some locations
<i>Drosera micra</i>	peat	sand is present in the soil
<i>Drosera micrantha</i>	pale sand	
<i>Drosera microscapa</i>	peat	sand is present in the soil
<i>Drosera miniata</i>	laterite	clay under laterite
<i>Drosera minutiflora</i>	pale sand	

Table 1. Continued.		
Species	Soil type preference	notes
<i>Drosera nitidula</i>	yellow sand	clay mixed in with soil
<i>Drosera nivea</i>	yellow sand	
<i>Drosera occidentalis</i>	peat	
<i>Drosera omissa</i>	pale sand	
<i>Drosera oreopodion</i>	pale sand over laterite	
<i>Drosera paleacea</i>	peat	sand mixed in with soil
<i>Drosera patens</i>	pale sand	
<i>Drosera pedicellaris</i>	pale sand	
<i>Drosera platystigma</i>	laterite over sand	high clay content in sand
<i>Drosera pulchella</i>	peat	can grow in sand and laterite
<i>Drosera pycnoblasta</i>	pale sand	
<i>Drosera pygmaea</i>	peat	
<i>Drosera rechingeri</i>	pale sand	
<i>Drosera roseana</i>	peat	sand is present in soil
<i>Drosera sargentii</i>	pale sand	
<i>Drosera scorpioides</i>	laterite over pale sand	
<i>Drosera sewelliae</i>	laterite	
<i>Drosera silvicola</i>	laterite	
<i>Drosera spilos</i>	laterite	can grow in yellow sand
<i>Drosera stelliflora</i>	laterite	
<i>Drosera trichocaulis</i>	pale sand	occasionally in laterite
<i>Drosera verrucata</i>	pale sand	high clay content
<i>Drosera walyunga</i>	laterite over pale sand	

al. 2014). It is thought that in these landscapes natural selection has favored limited seed dispersal, resulting in elevated persistence of lineages and high numbers of localized rare endemics (Hopper 2009).

There are two types of sandplain in this region. Coastal sandplains, where the pale sand is of a marine origin, deposited as dunes as long as 2 million years ago until the present. Over time, the original nutrients eroded away and the soil pH declined. Inland sandplains originated from the ancient continent towards the east, and extend in a broad belt from Shark Bay to west of Esperance. The soils of inland sandplains are typically yellow deep sands, pale deep sands, and yellow sandy earths (Wyrwoll *et al.* 2014) and profiles often contain ferricrete or ferruginous gravels.

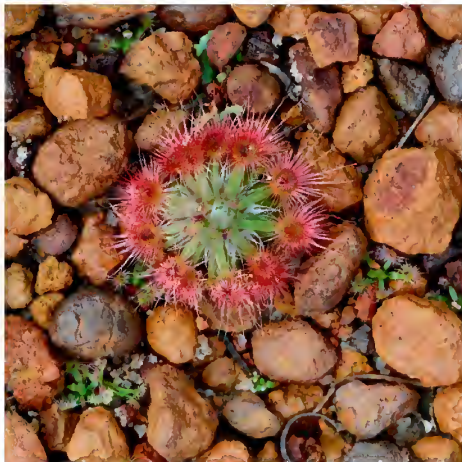
Plant life in south-west Western Australia has evolved on some of the world's oldest and most nutrient-impovertised sandy soils. The availability of phosphorus (P) is particularly low on these sandy soils, but soil nitrogen (N), potassium (K), and micronutrients are also notoriously scarce (McArthur 1991). The extreme infertility of these soils is primarily due to the low nutrient content



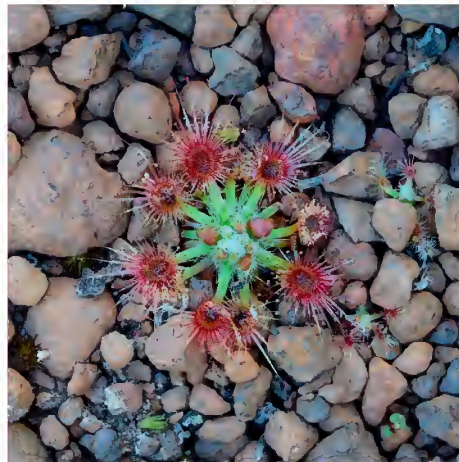
Drosera nivea only grows in yellow sands in a small area south of Coorow, WA. All photos in this article are by Richard Nunn.



Drosera citrina growing in yellow sand near Moora, WA. This is the only yellow flowered species in the Pygmy *Drosera* complex.



A recently described species, *Drosera coomallo* favors laterite soils. Photo taken along the Brand Highway, WA



Drosera hyperostigma is a commonly occurring species of Pygmy *Drosera*, that grows in laterite. Photo taken near Bridgetown, WA.

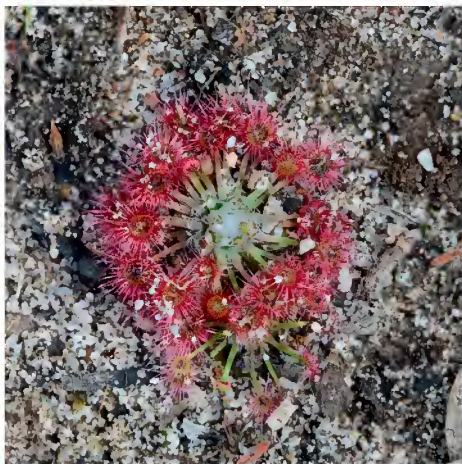
of the parent material that gave rise to the sand and to their old age and strong degree of weathering. Over time, weathering leads to the loss of key rock-derived nutrients (*e.g.*, P) in the absence of major soil-rejuvenating processes (*e.g.*, glaciations, volcanic eruptions) (Walker & Syers 1976; Laliberté *et al.* 2012). On the other hand, N, a nutrient derived from the atmosphere, is continuously lost from the system, predominantly as a result of fire, when most N is volatilized (Orians & Milewski 2007). Nitrogen fixation is therefore crucially important to compensate for these losses.



Drosera sewelliae growing in heavy laterite. Photo taken near Muchea, WA.



An example of mixed soil types, *Drosera leucoblata* prefers pale sand based soils with a high peat and organic matter content. Photo taken at Cranbrook, WA.



The ubiquitous *Drosera pygmaea*, is the only Pygmy *Drosera* species found outside of WA, this species prefers peat based soils.

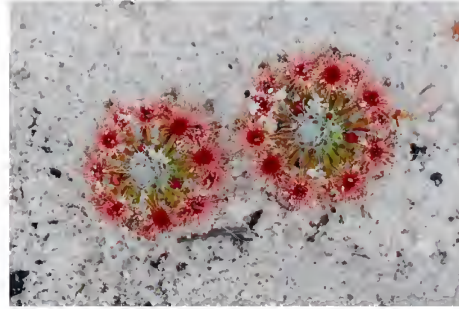


Drosera roseana growing in peat based soil near Northcliffe, WA.

Given that extreme soil infertility imposes a severe constraint to plant growth, one might expect the sandplain flora to show low diversity, comprising only a restricted number of plant species that evolved the necessary adaption(s) to successfully grow on these soils. Yet, the exact opposite is actually found, and a key feature of sandplains are their exceptionally high degree of floristic and functional diversity (Lambers *et al.* 2010). Interestingly, the greatest plant diversity on the sandplains is found on the most severely P-impooverished soils (Laliberté *et al.* 2014; Lambers *et al.* 2014; Zemu-



Drosera minutiflora specializes in growing in pale sand. Photo taken near Cataby, WA.



Drosera closterostigma is another pale sand growing species endemic to the sandplains north of Perth. Photo taken at the type location near Cataby, WA.

nik *et al.* 2015). Pygmy *Drosera* species are no exception and have developed an extensive roster of endemic species in this harsh low-nutrient environment.

Carnivory in south-west Western Australian flora

One particular nutrient-acquisition strategy displayed by species in nutrient deficient soils is carnivory. This strategy is far more common in south-west Western Australia and particularly in *Drosera*, than it is in the rest of the world. Based on the total number of species in the Southwest Australian Biodiversity Hotspot, one can calculate how many carnivorous species one might expect, based on global averages. However, there are in excess of four times more carnivorous species than expected (Lambers *et al.* 2014). Carnivorous species have diversified tremendously during the course of evolution in south-western Australia, and the Pygmy *Drosera* species are an excellent example of this diversification in action. The low fertility of the region and tens of millions of years of climatic stability and a lack of major disturbances such as glaciation and volcanic activity have allowed diversification of a range of species and nutrient-acquisition strategies, including carnivory.

Pygmy *Drosera* soil type preferences

Pygmy *Drosera* species have evolved on sands and ironstone and it can be observed that some species are endemic to pale (white) sands, some species to yellow sand, and others to laterite/ironstone gravel (Table 1). A few species have evolved on peat-based soils in the coastal swamps found in the region, but there is nowhere near the species density that can be found on sand and laterite. The occasional species has formed the ability to populate multiple soil types.

Conclusion

The rich diversity of Pygmy *Drosera* species on the nutrient impoverished soils of south-western Australia is a result of the age and long-term climatic and tectonic stability of this region and the ability of the genus to evolve carnivory as a strategy to acquire nutrients. The greatest diversity and evolution of Pygmy *Drosera* species can be seen on the sandplains and laterite gravel outcrops, which are both low in P availability. Fewer species occur on younger, higher-nutrient peat and loam-

based soils in the swamps of the region or on the youngest dunes formed over the past 7,000 years since the last glacial maximum.

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UNEXPECTED DISCOVERY OF 7-METHYLJUGLONE (RAMENTACEONE) IN SEVERAL AUSTRALIAN SUNDEWS

JAN SCHLAUER • Zwischenstr. 11 • D-60594 Frankfurt/Main • Germany • jan@carnivorousplants.org
SIEGFRIED R. H. HARTMEYER and IRMGARD HARTMEYER • Wittlinger Str. 5 • D-79576 Weil am Rhein
• Germany • s.hartmeyer@t-online.de

Keywords: Metabolism, phytochemistry, naphthoquinones, *Drosera*, chemotaxonomy.

Introduction

Naphthoquinones are characteristic constituents that have been detected in numerous plant families. There are at least four fundamentally different biosynthetic routes that lead to the naphthoquinone skeleton (Durand & Zenk 1974). Some naphthoquinones are formed via the acetate-poly malonate (= polyketide) pathway, and plant families notoriously known for containing such acetogenins are Iridaceae, Ebenaceae, Plumbaginaceae, Droseraceae, Nepenthaceae, Drosophyllaceae, Dioncophyllaceae, and Ancistrocladaceae. While all these families include species that form plumbagin (= 2-methyljuglone, Fig. 1), its regioisomer 7-methyljuglone (= ramentaceone, Fig. 1) has so far only been detected in Ebenaceae, Nepenthaceae, and Droseraceae (Schlauer *et al.* 2005).

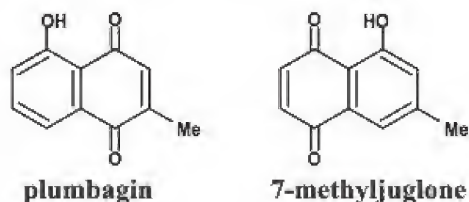


Figure 1: Chemical structures of naphthoquinones detected in different *Drosera* species; plumbagin and 7-methyljuglone.

Since the classical investigations (Zenk *et al.* 1969; Durand & Zenk 1974; Culham & Gornall 1994) it has been known that the different naphthoquinone isomers are characteristic for several sundew (*Drosera* L.) species (or species groups), and can thus be used for chemotaxonomic delimitation and distinction (Schlauer & Fleischmann 2016). The most striking parallels between chemism and systematics are found in the so-called “Australian clade” (*Drosera* subgenus *Ergaleium* (DC.) Drude) that contains all pygmy (*D.* section *Bryastrum* Planch.) and tuberous (*D.* sections *Ergaleium* DC., *Erythrorhiza* (Planch.) Diels, and *Stolonifera* (Planch.) DeBuhr) species together with their relatives (e.g., the fork-leaved sundew, *D. binata* Labill., *D.* section *Phycopsis* Planch., Rivadavia *et al.* 2003). While the pygmy species and their immediate relatives, the *D. petiolaris* RBr. ex DC.-group (*D.* sect. *Lasiocephala* Planch.) apparently all lack acetogenic naphthoquinones whatsoever, the tuberous species together with the fork-leaved sundews (*D.* sect. *Phycopsis* Planch.) typically contain plumbagin and not 7-methyljuglone. *Drosera glanduligera* Lehm., an endemic of southwestern Australia and a supposed, isolated member of *D.* subgen. *Ergaleium* (sole member of *D.* sect. *Coelophylla* Planch.), has not been investigated for its naphthoquinones so far, probably because it used to be rare in cultivation. We have now embarked to close this gap, as the species has become a working horse of biomechanics for its rapid tentacle movement (Poppinga *et al.* 2012), and methods have been developed to cultivate this intriguing species (Hartmeyer *et al.* 2013).

Another group of species consists of relatives of the palaeotropical species *D. indica* L. (*D.* sect. *Arachnopus* Planch.) in the other large *D.* subgenus *Drosera*. Recently it has been recognized that a

considerable diversity exists among Australian representatives of section *Arachnopus*, and numerous of the taxa occurring there have been described as separate species (Schlauer 2001; Barrett & Lowrie 2013; Lowrie 2014). In previous phytochemical investigations in *D.* sect. *Arachnopus* different naphthoquinones (plumbagin or 7-methyljuglone, respectively) have been reported by different researchers (Zenk *et al.* 1969; Culham & Gornall 1994) who have, however, labelled all these diverse plants as a single collective species “*D. indica*”, and as the exact provenance and identity of these plants cannot be reconstructed with certainty it was decided to re-investigate the section, now with appropriately identified plant material.

Materials and methods

All plants used in the present study are annual or short-lived and have been grown from seed. Fresh leaves of *D. glanduligera* Lehm., *D. aquatica* Lowrie, *D. cucullata* Lowrie, *D. finlaysoniana* Wall. ex Planch., *D. fragrans* Lowrie, *D. hartmeyerorum* Schlauer, and *D. serpens* Planch. were detached from rosettes or stems of mature (flowering size) plants and (ca. 50 mg fresh weight, each) extracted within the next few days in 100 µl of hydrotreated light naphtha (petroleum, boiling point range 60-95°C, PZN 7284064 from O. Fischar GmbH, Saarbrücken, Germany, CAS No. 64742-49-0) overnight at 20°C. Extraction supernatants (20 µl each) were spotted to a silica-gel aluminum-backed TLC plate (SIL G/UV254, 0.20 mm, 4 × 8 cm, REF 818 131, Macherey-Nagel, Düren, Germany), focused for spot sharpening with methanol (anhydrous, 99.8%, Sigma-Aldrich, Steinheim, Germany, CAS No. 67-56-1) and developed with toluene (anhydrous, 99.8%, Sigma-Aldrich, Steinheim, Germany, CAS No. 108-88-3). Detection of quinones was enhanced by reacting the dried plates with ammonia gas (Borntraeger reaction). Quinones were identified by comparison to co-chromatographed extracts of *D. intermedia* (used as standard for plumbagin, RF = 0.54) and *D. rotundifolia* (standard for 7-methyljuglone, RF = 0.46) that had been analyzed and confirmed by GC-MS previously (Schlauer *et al.* 2005).

Results

Naphthoquinones were detected in all investigated samples as summarized in Table 1.

Table 1. Species investigated and naphthoquinones detected.		
Section	Species	Naphthoquinone
<i>Drosera</i> subgen. <i>Ergaleium</i> sect. <i>Coelophylla</i>	<i>D. glanduligera</i> Lehm.	7-methyljuglone
<i>Drosera</i> subgen. <i>Drosera</i> sect. <i>Arachnopus</i>	<i>D. aquatica</i> Lowrie	7-methyljuglone
	<i>D. cucullata</i> Lowrie	plumbagin
	<i>D. finlaysoniana</i> Wall. ex Planch.	plumbagin
	<i>D. fragrans</i> Lowrie	plumbagin
	<i>D. hartmeyerorum</i> Schlauer	7-methyljuglone
	<i>D. serpens</i> Planch.	plumbagin

Discussion

The detection of 7-methyljuglone in *D. glanduligera* elucidates the naphthoquinone chemism of the last section of *Drosera* hitherto unexplored in that respect and it is at the same time a great surprise, as *D.* subgenus *Ergaleium* was hitherto characterized by either total absence of any acetogenic naphthoquinone (in pygmy species) or by the almost exclusive presence of plumbagin only (in tuberous and fork-leaved species). This confirms the eccentric position of *D.* section *Coelophylla* in subgenus *Ergaleium*.

The naphthoquinones detected in the investigated species of *D.* section *Arachnopus* confirm the chemical diversity that has previously been described for “*D. indica*” s. lat. and now for the first time attribute the different isomers to distinct identified species. Apparently the formation of 7-methyljuglone is limited to a minority of species within *D.* sect. *Arachnopus* (so far only detected in *D. hartmeyerorum* and *D. aquatica*) and among Australian sundew species in general. In the same subgenus *Drosera*, the presence of both isomers (usually in different species) has parallels in *D.* section *Prolifera* that is endemic to Queensland and in section *Drosera* that is most speciose outside Australia (Culham & Gornall 1994).

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MANY TRIGGERPLANTS (*STYLIDIUM* spp.; STYLIDIACEAE)
FORM ARBUSCULAR MYCORRHIZAL ASSOCIATIONS

STEPHEN P. MOBERLY • Department of Psychiatry • Indiana University School of Medicine • Indiana University-Purdue University Indianapolis • Goodman Hall • 355 W. 16th St. • Suite 4800 • Indianapolis • Indiana 46202 • USA

MAXINE WATSON • Department of Biology • Jordan Hall • Indiana University • Bloomington • Indiana 47405 • USA

DOUGLAS W. DARNOWSKI • Department of Biology • Indiana University Southeast • New Albany • Indiana 47112 • USA • ddarnows@ius.edu

Keywords: triggerplant, *Stylidium*, AM-fungi, mycorrhizae, carnivorous.

Introduction

Triggerplants (*Stylidium* spp.; Stylidiaceae) grow in Australia and a few areas to its north, though >95% of the >300 species in the genus *Stylidium* are endemic to Australia (Darnowski 2002). Their name comes from the extremely rapid, active, and resettable pollination mechanism which they use. In addition, they have been recently recognized as possessing at least some of the traits of carnivorous plants, specifically the ability to trap and digest prey insects (Darnowski *et al.* 2006), as well as the more recently-demonstrated ability to transport and, therefore, benefit, from nutrients obtained in that way (Darnowski 2017). Generally, they trap prey which are much smaller than their pollinators. Triggerplants typically are found in extremely nutrient poor conditions where genera such as *Drosera* and *Utricularia* are usually found in the same places.

In these nutrient-poor conditions, associations between plants and arbuscular-mycorrhizal fungi are common. Such mycorrhizal associations are widespread and considered to be classic examples of a mutualism between plants and fungi (Taiz & Zeiger 2010). The plants provide all the carbon to support fungal growth. In turn, arbuscular mycorrhizae (AM)-fungal hyphae penetrate plant root cells and extend into the soil matrix, effectively increasing root surface area and mineral uptake potential. It is well known, for example, that mycorrhizal inoculation of trees can greatly enhance survival and post-inoculation growth after transplantation (Taiz & Zeiger 2010). The carbon demands of the fungus can be high, taking up as much as 20% of the assimilate fixed by the plant.

Thus, mycorrhizae are most persistent when plant nutrient demand is high and photosynthesis can be carried out efficiently. Under shade or higher nutrient conditions, plants may shed mycorrhizae and the relationship becomes facultative (Watson *et al.* 2001). Little is known about whether triggerplants form mycorrhizae, but the conditions which they prefer, bright light and low nutrients, favor both AM formation and carnivory.

The authors examined ten species of triggerplants grown in the greenhouse and not specifically inoculated with AM-fungal spores. These species were selected to give a range of species 1) from different sections of the genus *Stylidium* and 2) from different geographic regions of Australia, in order to assess whether formation of mycorrhizae is likely to be a general phenomenon.

Materials and methods

Plants were greenhouse grown (Darnowski 2003) in Corydon, Indiana, USA. They were started in the US either from seed or from greenhouse-grown stems which lacked roots at the start of the experiment, so any fungi associated with the plants would have come from either the soil mix used (not autoclaved) or from sources within the greenhouse. Ten species, all grown for >1 year in a 1:1 mix of silica sand and sphagnum peat were examined in total (see Table 2 for names). All subsequent steps were undertaken at room temperature (approximately 20-25°C). Roots were harvested and fixed in 95% ethanol for a minimum of 24 hr. To detect arbuscular mycorrhizal fungi (AMF), roots were rinsed in deionized water and stained using a mixture of 80% (by volume) solution A, and 20% (by volume) solution B. Solution A was 0.3% (by mass) aniline blue in 90% ethanol. Solution B was Lactophenol Blue Solution (all solutions from FLUKA, Fuchs, Switzerland; Marx 1982; Nemec 1982; Ruzin 1999).

Three 1 cm sections of root were selected randomly from each species and used for analysis. Sections were stained for approximately 30 min. then washed in deionized water for approximately 5 min. to remove excess stain. Roots were examined using a student-grade Nikon compound microscope, first at 100× total magnification and then at 1000× for scoring. Fields of view for scoring were chosen randomly by moving the travel controls on the microscope randomly and then scoring the image found as long as root tissue filled the field of view. Images were taken using a Nikon EOS Digital Rebel. Images were cropped and adjusted for levels and brightness and contrast using Adobe Photoshop (San Jose, California, USA).

Fungal colonization was measured using a numerical scale as defined in Table 1, and each of the three samples per species showed similar staining for each of the species examined. The number reported in Table 2 is a typical one for the species, chosen as being either the same as three identical scores or as the midpoint among the three scores if they differed. Ecto- and endomycorrhizae (AM) were distinguished by using the microscope fine focus, with ectomycorrhizae (not counting towards the scores in Table 2) being exclusively on the outside of the root, not penetrating any cells.

Table 1. Definitions for scoring of levels of mycorrhiza formation.	
Mycorrhiza Formation Score	Definition, per 3 cm of root
0	No staining or staining structures other than mycorrhizae.
1	1-3 cells in field of view with mycorrhizal infection
2	4-5 cells in field of view with several AM structures per cell or a similar total number of AM structures in a smaller number of cells
3	6-8 cells in field of view with several AM structures per cell or a similar total number of AM structures in a smaller number of cells
4	9-10 cells in field of view with several AM structures per cell or a similar total number of AM structures in a smaller number of cells
5-10	Several clusters of cells per field of view, each scoring from 1-4

*Note that more elaborately detailed or larger mycorrhizal clusters in a given cell raised the score for a field of view by 1.

Table 2. Mycorrhiza-formation scores for various species of triggerplants grown in the greenhouse. Subgenera from Mildbraed (1908).			
<i>Stylidium</i> Species	Subgenus, Section of Genus <i>Stylidium</i>	Eastern, Western	Typical Score
<i>adnatum</i> R. Br.	<i>Nitrangium</i> , <i>Rhynchangium</i>	Western	4
<i>brunonianum</i> Benth.	<i>Tolypangium</i> , <i>Echinospermum</i>	Western	0
<i>bulbiferum</i> Benth.	<i>Nitrangium</i> , <i>Thyrsiformes</i>	Western	4
<i>caespitosum</i> R. Br.	<i>Tolypangium</i> , <i>Lineares=Stylidium</i>	Eastern	4
<i>debile</i> F. Muell.	<i>Tolypangium</i> , <i>Debiles</i>	Eastern	4
<i>graminifolium</i> Sw.	<i>Tolypangium</i> , <i>Lineares=Stylidium</i>	Eastern	3
<i>lineares</i> Sw. ex. Willd.	<i>Tolypangium</i> , <i>Lineares=Stylidium</i>	Eastern	3
<i>scandens</i> R. Br.	<i>Tolypangium</i> , <i>Verticillatae</i>	Western	10
<i>soboliferum</i> F. Muell.	<i>Tolypangium</i> , <i>Lineares=Stylidium</i>	Eastern	2
<i>uniflorum</i> Sond.	<i>Nitrangium</i> , <i>Thyrsiformes</i>	Western	10

Results

From Table 2, it can be seen that all but one of the nine species examined, the exception being *S. brunonianum*, formed mycorrhizae when grown in the greenhouse, with wide variation from species to species in the extent of the mycorrhizae formed. Some, including *S. graminifolium* and *S. scandens*, formed very extensive networks, while other species, such as *S. soboliferum*, had much more modest colonization. Examples of highly infected cells and tissues can be seen in Figure 1.

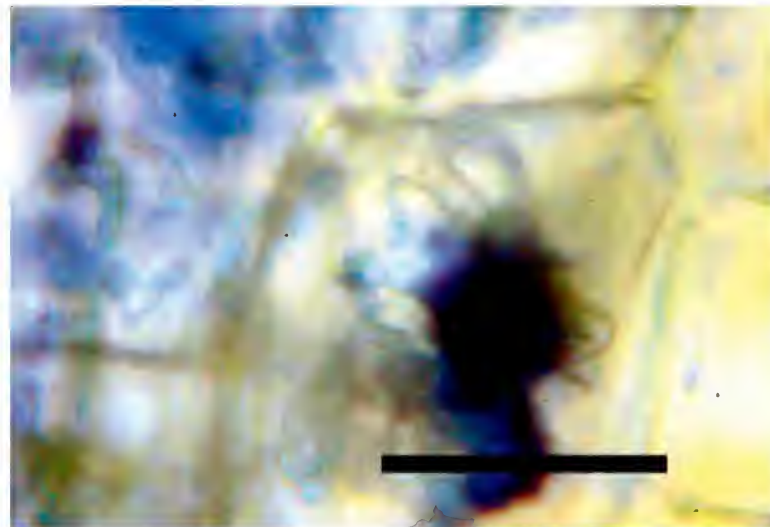


Figure 1: Roots from *Stylidium scandens* grown in the greenhouse in Corydon, Indiana, USA, colonized by mycorrhizal fungi (sample scored 7). The roughly rectangular structures are the plant cells, and the curved and coiled structures within them are the AM mycorrhizal hyphae. Bar = 5 μ m.

Discussion

From the observations presented, many species of *Stylidium*, from at least two of six subgenera, including the largest subgenus of *Stylidium* (*Tolypangium*) and a total of six sections, are able to form mycorrhizae. These plants come from temperate regions in both eastern and western Australia. This greatly expands on the meager existing literature on mycorrhizae in *Stylidium*, which simply states that *S. graminifolium* could form synthesized associations with the mycorrhizal fungus *Labryinthomyces* sp. (Kope & Warcup 1986) and that *S. soboliferum* and *S. perpusillum* formed mycorrhizae in the field (Warcup 1980). While *S. graminifolium* and *S. soboliferum* are also considered in this work, providing a useful confirmation of Warcup's (1980) data, *S. perpusillum* adds an ephemeral, temperate species from yet another subgenus, *Centridium*.

In addition, data obtained in other experiments on tropical *S. fimbriatum* (Subgenus *Andersoniana*) show that that species also forms abundant mycorrhizae, at a score of about 9 (Table 1; data not shown). Thus, triggerplants from all areas of Australia, including both tropical and temperate places, are capable of forming mycorrhizae.

Even more interestingly, Kope & Warcup (1986) and Warcup (1980) only reported ectomycorrhizae, while the authors of this paper found endomycorrhizae. There is precedent for this finding, as has been seen *in vivo* and/or *in vitro* for the woody genera *Acacia* and *Eucalyptus* (Boudarga *et al.* 1990; Founoune *et al.* 2002; dos Santos *et al.* 2001). These two genera are both very successful in the flora of Australia, as is *Stylidium*. In both of these woody genera, early associations favored endomycorrhizae, with a shift to ectomycorrhizal associations in older plants; it would be instructive to follow AM formation in *Stylidium* for a longer period of time to determine if this pattern is repeated by *Stylidium*.

The numbers presented here are based on plants grown in the greenhouse, not the field, and all of them were grown from seed in North America. For this reason, these numbers do not rule out that a particular species, here *S. brunonianum*, can form mycorrhizae, and the relative abundance of mycorrhizae in the field in Australia will probably vary from the data shown here since different species of mycorrhizal fungi and different numbers of spores will probably be available.

It is also interesting to note that, overall, the eastern species examined, which come from more fertile soils, scored lower (2-4) than the western species scored (4-10), which live on older and more depleted soils. This could be a genetically-determined feature which would make sense given that western species need more of the nutrients which AM help to provide.

Nevertheless, the fact that triggerplants can form mycorrhizae adds an extra dimension to their ecological interactions. Given the existence of important parts of the carnivorous syndrome in triggerplants (Darnowski *et al.* 2006; Darnowski 2017) and their unusual pollination mechanism, there are a range of combined ecological interactions to be studied in these plants, such as the use of nutrients from prey organisms by mycorrhizae or the reliance on mycorrhizae for nutrients which are important for processes which enhance the attraction of pollinators. Some of these experiments are already underway.

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FURTHER EVIDENCE OF CARNIVORY IN TRIGGERPLANTS
(*STYLIDIUM* SPP.; STYLIDIACEAE)

DOUGLAS W. DARNOWSKI • Department of Biology • Indiana University Southeast • 4201 Grant
Line Road • New Albany • Indiana 47150 • USA • ddarnows@ius.edu

Introduction

Triggerplants (*Stylidium* Sw.; Stylidiaceae) grow from Southeast Asia through Australia, with well over 100 species in the genus. Almost all species make sticky hairs on parts of their inflorescences. These sticky hairs trap small insects, much smaller than the flowers' normal pollinators, which include arthropods such as bee flies. Digestive enzymes have been detected in this genus in the area of sticky hairs where prey are trapped (Darnowski *et al.* 2006).

Field observations in Australia almost unfailingly show that triggerplants grow alongside known carnivores, such as *Drosera* and *Utricularia* (Darnowski 2002; Darnowski *et al.* 2006). That ecological association is another indicator that triggerplants may be truly carnivorous, using their sticky hairs to obtain extra nutrients while growing on nutrient-poor soils.

To prove that triggerplants are carnivorous plants, it must be demonstrated they uptake nutrients from prey, and that there is a benefit being derived from those nutrients (Plachno *et al.* 2009; Adamec 2013).

This work uses heavy-isotope amino acids to look for nutrient uptake by triggerplants in the same region in which they have their trapping hairs.

Materials and methods

¹³C-alanine (Cambridge Isotope Laboratories, Tewksbury, Massachusetts, USA) was provided to flowering plants of *Stylidium fimbriatum* and *S. debiles* by soaking a small piece of Whatmann #1 filter paper in a solution of the amino acid so that each plant received 30 mg of ¹³C-alanine. This heavy amino acid can be traced in the plant by mass spectrometry (MS), since ¹³C is rare in nature and easy to differentiate by MS from normal ¹²C.

The filter paper containing the labelled amino acid was applied to the area of sticky hairs, which is the same region in which digestive enzymes have been observed.

Three days later, plants were separated into shoots and roots and then freeze-dried. Because of the small plant size, three plants were pooled per species and the results reported as a whole. ¹³C was detected in the various samples using MS (UC Davis Stable Isotope Facility, University of California-Davis, Davis, California, USA), and the amount detected was converted to give the percentage of the original sample detected.

Results and discussion

Stylidium debiles showed 20% of the initially-applied sample of ¹³C-alanine was detected in the shoot of the plant and 45% in the root (Fig. 1). *Stylidium fimbriatum* had 5% in the shoot and 20% in the root.

In both species of triggerplant examined, the plants took up the nutrients provided and translocated them to the roots. In fact, while the initial absorption must have occurred in the shoot,

broadly defined to include the inflorescence, most of the label found in the plant three days later was in the root, confirming transport of the nutrients by the plant. This strengthens the idea that triggerplants are carnivorous plants.

The portion of the initially-applied 30 mg of ^{13}C -alanine which was not detected in the plants may have been lost to cellular respiration. This idea is supported that a greater amount was not found in tropical *S. debiles* than in temperate/subtropical *S. fimbriatum* since tropical plants tend to lose more of their carbon to cellular respiration than other plants (Taiz & Zeiger 2010).

Further studies are needed to check uptake and translocation in more species, and ecological studies are needed to show some benefit from the uptake of nutrients from prey, such as increased biomass or the production of more seeds, but it can be said that triggerplants are probably carnivores.

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Figure 1: A drawing of *Stylidium debiles*. 20% of the initially-applied sample of ^{13}C -alanine was detected in the shoot and 45% in the root.

GROWING 20,000 *SARRACENIA* SEEDLINGS

CHRIS MCCARTHY • Sunnyvale • California • USA • chrismccarthy707@gmail.com

RICHARD WUYDTS • Founder and Production Manager • World's Rare Plants • Half Moon Bay
• California • USA • mawuydts@yahoo.com

Introduction

The goal of this paper is to demonstrate the ideal conditions necessary for cultivating large quantities of *Sarracenia* plants, and how Richard Wuydts, Production Manager at World's Rare Plants, through a number experiments over the course of several years, successfully and consistently grows 98 out of 100 viable seeds by manipulating the environment.

Sarracenia is a genus of carnivorous plants native to the south-eastern United States and Canada, commonly known for their “trumpet like” appearance. Using a series of biological mechanisms to catch their prey, this genus does not have any moving parts. Combining the color, scent, and extra floral nectaries and the upper lip of the “funnel” the plant attracts insects that fall inside and are digested by various enzymes.

While *Sarracenia* are considered relatively easy to grow given the right conditions, typical cultivation methods show a yield for this genus is 3 seeds will germinate out of 100. This plant requires moist-wet soil consistently, sunny conditions during growth with decreased light and temperatures during a dormant period.

Setup

To create the environment for these plants, Richard first took two 1.2 × 4.9 m nursery tables and elevated them using 12 cinder blocks, 6 on both sides of the table. The tables are edged by 5 × 5 cm wood blocks, and covered in 6 mil double ply plastic. Drains were installed to prevent seedlings from drowning, and with water falling onto the floor, it would increase the environment's humidity.

Richard then built Quonset huts or Hoop house to enclose the seedlings using schedule 40 PVC pipe, attaching them to the outer edges of the tables, and covering them with 6 mil single layer plastic. Proper enclosure is necessary in creating the ideal environment and temperature that the *Sarracenia* require.

Temperature control

The seed of *Sarracenia* require variable temperatures and controlling the temperature within the Quonset hut is imperative for maximum yield. Richard developed a customized heating system that automatically monitors and turns on the heaters to control the Quonset hut's distribution of heat.

By installing waterproof electrical outlets, Richard was able to install a heater that is 4.9 m long and 1.2 m wide across both tables. The heaters were closely monitored through the use of a temperature controller and probe in one of the seedling trays to evaluate soil temperature.

The *Sarracenia* seed require variable temperatures depending upon the thickness of the seed coating. To make sure that the *Sarracenia* seed were heated properly at any given time, Richard implemented an automatic shut off and re-start system when temperatures rose or fell. This allowed for a consistent heat of the soil at 22°C.

A fan was then installed centrally toward the top to control the temperature further, as well as eliminate stale air and fungus growth within the Quonset hut.

Water distribution

To generate the most effective end result, controlling the amount of water, time of distribution, and method of distribution is important.

Just as he developed a custom heating mechanism, Richard created a customized method of water distribution. Mist systems were attached to both tables that delivered light droplets to simulate a cloud like fog, which captures the ambient heat and rains on the seedlings.

Richard then installed a timer for the mist system that controlled the distribution of water. Delivery was set at 2 seconds per hour, from sunrise to sunset.

Humidity and environment

By controlling these two elements, Richard was able to create a consistent ambient temperature of 31°C, a water temperature of 26.7°C, and humidity above 80%. The heat and water distribution methods combine to create a unique atmosphere within the Quonset hut that is highly conducive to successful *Sarracenia* propagation.

Preparation of soil and seedlings

After the Quonset huts were prepared and optimized, Richard focused his attention on the final two important variables.

Using 28 × 61 cm plastic trays with holes in them, Richard added his seedling mix, which consisted of sifting peat moss, and two different types of kiln dried sand. This mix allowed Richard to move the plants without roots adhering to the soil in the next stage of planting, which he calls “dibbling.”

A layer of 38 mm of soil mix is placed in the tray. The medium is wet down, and the seeds are laid on top of the soil with a light dusting of the soil mix on top. Finally, the trays are placed on top of the heaters.

Seedling growth

Not all seeds are the same.

The majority of seedlings sprouted in the Quonset hut in soil temperatures of 22°C. The seeds that did not open were removed and placed in a similar set up, in a cooler area, to germinate in a more suitable environment.

Depending on the temperature at the time of pollination, the seed coatings will differentiate in thickness – so one tray of seedlings can last for the whole propagating season with different crops coming up at any given interval, depending on germination temperature.

Conclusion

Richard’s expertise of carnivorous plants and manipulation of the environment generated a huge increase in germination for this particular genus of plant, and he has perfected a repeatable method

of growth. What once was 3 out of 100 seeds germinating now becomes 98 out of 100 seeds germinating with this method. Mark Rubnitz, Director of San Francisco Botanical Gardens, tried this and was so successful that he brought Richard his remaining unplanted *Sarracenia* seeds.

To re-create similar propagation, it is imperative to develop methods of control over water, heat, and humidity.

Acknowledgement: A big thanks to Lois Ochs of Raccoon Ridge Nursery who contributed of all the *Sarracenia* seed used in this experiment.

About the authors

Richard Wuydts is the Production Manager and “Master Planter” at World’s Rare Plants, and is a renowned expert in carnivorous plant growth. He has over 50 years of experience in the landscaping/gardening arena, and has collected such a large variety of carnivorous plants that he and his wife, Mary, decided to start a business along with their partners Jan and Phil Small.

Chris McCarthy is a marketing professional in the technology industry, as well as a freelance writer, blogger, and editor.



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NEW CULTIVARS

Keywords: cultivar, *Sarracenia* 'Alicia', *Sarracenia* 'Berry Pastry', *Sarracenia leucophylla* 'Dionne', *Sarracenia* 'The Kraken', *Nepenthes* 'Mangomarginata', *Dionaea muscipula* 'Jurasick'.

Sarracenia 'Alicia'

Submitted: 10 November 2016

Sarracenia 'Alicia' was grown from seeds obtained from Cédric Azais in 2011. The parent plants are *Sarracenia moorei* and *S. leucophylla*. The plant produces many pitchers in spring and again in autumn. The pitchers typically grow to a height of 70 cm. The opened pitchers show a beautiful pink and white color (Fig. 1). With time the high part of the pitchers become very dark pink.

Named Alicia for the pink color preference of my wife.

Sarracenia 'Alicia' must be reproduced vegetatively to preserve the unique characteristics of this cultivar.

—OLIVIER BRES • 90 Che. Montmirail • 84150 Violes • France • dionacaredragon@aol.com



Figure 1: *Sarracenia* 'Alicia'.

Sarracenia leucophylla 'Dionne'

Submitted: 29 November 2016

Sarracenia leucophylla 'Dionne' is selected because of its intense coloration (Fig. 2). It was grown from seed (2010) from a selfed *Sarracenia leucophylla* clone. *Sarracenia leucophylla* 'Dionne' differed from the rest of the seedlings because of its intense pink coloration in autumn. Pitchers start like a great red and white *S. leucophylla*, but later the outside of the pitchers turns bright pink. The inside of the pitcher does not turn pink, but keeps the red and white coloration. The lid is also red and white colored, with a little pink near the edges. Pitchers grow about 60-70 cm tall.

In spring *Sarracenia leucophylla* 'Dionne' grows like a red tube *S. leucophylla* with smaller, deep red pitchers with white fenestration. Flowers are red colored, with some yellowish/red on the style and inside of the petals.

The name of *Sarracenia leucophylla* 'Dionne' is dedicated to my loving wife.

Sarracenia leucophylla 'Dionne' must be reproduced vegetatively to preserve the unique characteristics of this cultivar.

—RIES VAN OOL • Uden • The Netherlands • www.carnivories.com • rieske2@hotmail.com



Figure 2: *Sarracenia leucophylla* 'Dionne'.

Sarracenia 'The Kraken'

Submitted: 3 October 2016

Sarracenia 'The Kraken' is a hybrid of *Sarracenia readei* × 'Royal Ruby' which I made in the spring of 2000 and selected in 2007. This cultivar was previously known to collectors as *S. (readei* × 'Royal Ruby') Select.

This striking pitcher plant is a very vigorous and stocky grower averaging heights of 75-80 cm or more on well-established plants. Pitchers are green overlaid with bright white areolae directly under the peristome, inside and out, extending downward 5-8 cm (Fig. 3). The large, ruffled lid (operculum) is bright creamy white with deep reddish purple veins approximately 7.5-10 cm wide from side to side and 7.5-10 cm long from the back to the front with dark reddish purple non-bleeding veins. The fluted mouth is shiny dark red and attains comparable sizing with the lid. Coloration is highly influenced by the presence of *S. leucophylla* in the background of both parent plants.

The largest and most colorful pitchers are those produced in the later part of spring onward through the month of June and early July, but a secondary flush of colorful growth is observed in late summer (August-September), albeit they are not as robust as those produced earlier. The flowers are large and a beautiful shade of deep red.

Propagation must be done via division and cuttings in order to maintain this plant's unique features. This cultivar's epithet was coined in June 2016 as a recommendation from my friend and colleague Don Elkins to explore the names of the creatures of Greek mythology and more specifically the movie *Clash of the Titans*. Like a tentacled sea serpent rising from the murky depths...I have RELEASED The Kraken!

—PHIL FAULISI • Santa Clara County • California • USA • philfaulisi@gmail.com



Figure 3: *Sarracenia* 'The Kraken'.

Sarracenia 'Berry Pastry'

Submitted: 3 October 2016

Sarracenia 'Berry Pastry' is a primary *Sarracenia moorei* hybrid of *Sarracenia leucophylla* × *flava* var. *rubricorpora* which I made in the spring of 2002 and selected in 2008. This clone was previously released under the former name *Sarracenia moorei* "Future Cultivar".

This beautiful and very popular pitcher plant, which now resides in dozens of collections, is a very vigorous grower, but not as large as other *S. moorei*. Spring pitchers on adult plants will average heights of 50-60 cm or more on well-established older plants. Pitchers are green overlaid with dark red veins on the upper portion of the tubes extending down both inward and outward 5-8 cm and bright white areolae directly under the peristome also extending down both inward and outward 5-8 cm (Fig. 4). The incredibly beautiful lid (operculum) is large, ruffled and bright creamy white with deep magenta veins approximately 7.5-10 cm wide from side to side and 7.5-10 cm long from back to front (Fig. 5). At maturity they flare slightly upward along their sides. The fluted peristome is slightly smaller than the lid averaging 6.25-7.5 cm wide and is dark red when fully colored. There is a prominent dark purple throat patch on the inside neck of the pitcher which runs up the inside of the lid. Flower sepals are rosy red with a prominent golden yellow stripe down each center, and rose red petals fading into lemony orange at their tips.

As the pitchers mature, the lid colors intensify into a breathtaking combination. Like all *S. moorei*, this cultivar produces pitchers all season with a more pronounced late summer burst of growth. These late season pitchers are not quite as large, but my personal observation over the years is that they are produced in great abundance and are much more colorful, especially if sunlight intensity is bright and temperatures are cooler.

Propagation must be done via division and cuttings in order to maintain this plant's unique features. This cultivar's epithet was coined on Facebook on 22 April 2016 by Carson Trexler as a suggestion that the lids reminded him of a berry pastry dusted with powdered sugar.



Figure 4: *Sarracenia* 'Berry Pastry'.



Figure 5: *Sarracenia* 'Berry Pastry' lid detail.

—PHIL FAULISI • Santa Clara County • California • USA • philfaulisi@gmail.com

Nepenthes 'Mangomarginata'

Submitted 7 December 2016

I germinated a batch of *Nepenthes albomarginata* seeds in May 2014 from Sumatra, Indonesia and one plant stood out from the rest. It has a red pitcher body, green peristome, and an orange marginal band instead of a white one (Fig. 6). Under typical T5 lighting the orange band becomes more prominent.

The name Mangomarginata, coined in November 2016 for the orange margin of the pitcher, was derived from the Mango fruit which is often red, green, and orange.

—MICHAEL ARONESTY • 752 14th Street • Manhattan Beach • California 90266 • USA • mike@southbaytraps.com



Figure 6: *Nepenthes* 'Mangomarginata' with orange band (left) and *Nepenthes albomarginata* with white band (right).

Dionaea muscipula 'Jurasick'

Submitted: 22 November 2016

Dionaea muscipula 'Jurasick' (Fig. 7) was discovered among my Venus flytrap seedlings in February 2012. The plant was really different because of the shape of the trap, which looks like *Dionaea muscipula* 'Alien'. Furthermore, we observe that the plant has small teeth; sometimes they don't exist or they can face in all directions. The rosette leaves are really compact and prostrate during all seasons. We note that the lower limb is notched during the summer. The plant has a beautiful light pink tint in summer and becomes dark pink in the late fall.

The name Jurasick is a combination of Jura, a French mountain near my house, and sick because the plant has a deformity. This name is also a pun because the teeth reminds me of a dinosaur from the Jurassic.

—JULIEN MÜLLER • Châtillon en Michaille •
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Figure 7: *Dionaea muscipula* 'Jurasick'

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